

APPENDIX 9-A. WATER HEATER FUEL SWITCHING ANALYSIS

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APPENDIX 9-A. WATER HEATER FUEL SWITCHING MODEL

9-A.1 INTRODUCTION

To the extent that revised energy conservation standards result in an increase in the price of a covered product compared to a competing product, some consumers (or home builders in the case of new construction market) may purchase the competing product. DOE's analysis seeks to account for such "product switching."

9-A.2 FUEL SWITCHING BETWEEN GAS AND ELECTRIC STORAGE WATER HEATERS

Two of the four product classes for water heaters compete to some extent. The competing classes are gas-fired storage water heaters and electric storage water heaters. It is useful to consider the nature of the competition in the replacement and new construction market segments separately in order to assess the potential impact of energy conservation standards on shipments.

9-A.2.1 Replacement Market

When it comes time to replace a gas-fired storage water heater, switching to an electric product involves substantial cost because of the complexity involved in modifying the installation.¹ Ordinarily, 30-amp electric wiring is not available near an existing gas-fired water heater. Providing such a circuit is expensive, and the main electric service panel may be inadequate for accepting the circuit. In addition, because it takes more time for an electric storage water heater to recover heated capacity, a larger electric tank is required to replace a gas unit. Therefore, changing from a gas-fired unit to an electric one entails significant expense. Consumers might be induced to switch from gas to electric only if there was a large increase in the price of a gas-fired water heater compared to an electric one. Because DOE does not envision a set of revised energy conservation standards that would result in such an increase, its analysis did not include switching from a gas-fired to an electric storage water heater in the replacement market.

Switching from an electric storage water heater to a gas-fired water heater also may occur in the replacement market. DOE's life-cycle cost (LCC) analysis indicates that the energy efficiency provided by electric heat pump water heaters produces large average LCC savings. Because this type of product in most cases has a higher total installed cost than does a typical gas-fired storage water heater and is relatively new to consumers and builders, DOE analyzed the potential for switching from an electric heat pump water heater to a gas-fired water heater. DOE considered all the potential combinations of switching from the max tech electric heat pump water heater standard level (2.35 EF at 50 gallon) to each of the gas-fired storage water heater standard levels.

DOE used data from the EIA's 2005 Residential Energy Consumption Survey (RECS 2005) to estimate the percentage of households expected to purchase an electric water heater in the base case that could switch to a gas-fired water heater. First, all households that use an

electric water heater were selected, assuming that those households reasonably represent future users of electric water heaters. Then, households that have no gas hookup were removed because they would be unlikely to switch to gas-fired water heating. Finally, households that had no central gas-fired furnace or boiler were removed, because the cost of venting and gas piping for a gas-fired water heater would be prohibitive. The remaining households—those that could switch to gas water heating—account for about 13 percent of the total households that have electric water heaters.

To estimate how many of the households that could switch to gas-fired water heaters would do so, DOE considered the difference in installed cost between a gas-fired storage water heater and an electric heat pump water heater in each of the combinations listed above. To do this, DOE performed a Monte Carlo simulation comparing installation costs for each household in the RECS 2005 subsample for electric water heaters. If the total installed cost of the electric heat pump water heater was greater than that of the gas-fired storage water heater, DOE assumed that a switch would occur. See Figure 9-A.1.1.

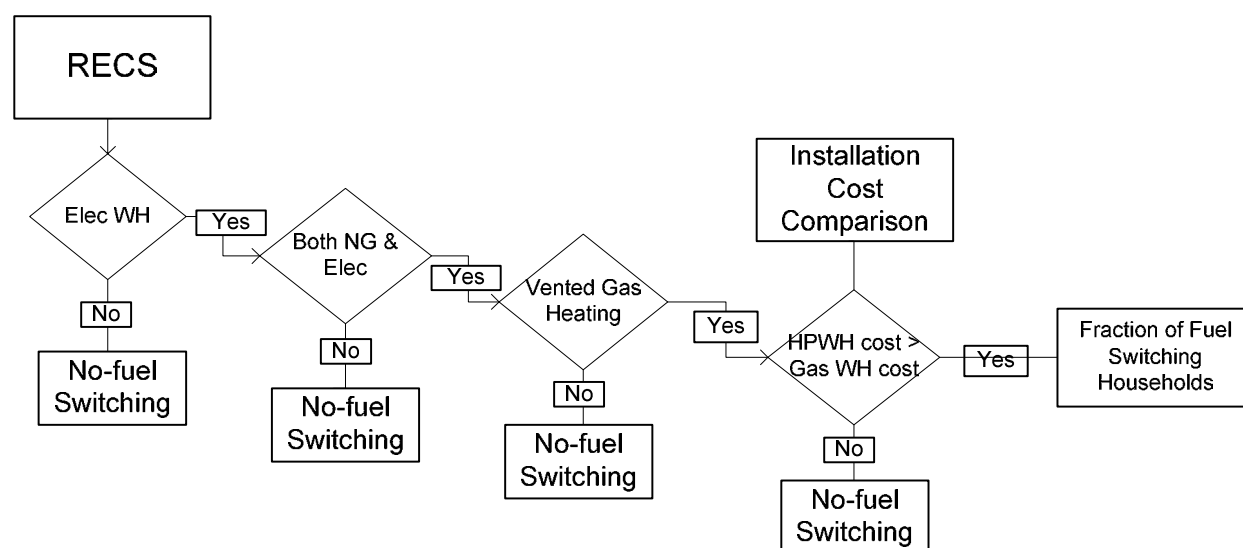


Figure 9-A.2.1 Electric to Gas Storage Water Heater Fuel Switching Flowchart

9-A.2.2 New Construction Market

For home builders, the choice of a water heater depends primarily on the availability of natural gas.¹ If gas is available, builders generally will install a gas-fired water heater (and usually a gas furnace). If gas is not available, but the utility says that it will be available soon, the developer will install a temporary central propane tank until natural gas is available. If natural gas will remain unavailable for the foreseeable future, as is the case in parts of the Pacific Northwest and Florida and in most rural areas of the United States, builders usually will install an electric water heater.

Price has little effect on the builder's choice of water heater because generally the water heater is a small part of the total cost for plumbing a new house. The builder pays attention

primarily to the total plumbing cost, not individual components. Small changes in the cost of the water heater therefore are unlikely to induce a builder to switch to a different product.

To assess the likelihood that a builder would switch from an electric heat pump water heater to a gas-fired storage water heater in new home construction, DOE first developed a sample of RECS households to serve as a proxy for future new homes that have electric water heating.^a Then households were selected that potentially could switch from electric to gas-fired water heating because natural gas is available. This group contains 7 percent of all RECS households in the sub-sample that has electric water heating (most new homes that have electric water heating do not have access to natural gas). Similarly to the replacement case, DOE performed a Monte Carlo simulation comparing installation costs for each household in the RECS 2005 subsample for electric water heaters. In total, DOE estimated that less than one percent of new homes with electric water heating would switch.

9-A.2.3 Summary of Estimated Water Heater Fuel Switching

Table 9.A.2.1 summarizes the percentage of electric water heater shipments in the base case that DOE estimates would be switched to gas-fired storage water heaters for each of the standards combinations.

Table 9-A.2.1 Estimated Percent of Base Case Electric Water Heater Shipments that Would Switch to Gas-Fired Water Heaters

Technology Combination Resulting from Standards	Percent that Switch (%)	
	New Construction	Replacements
HPWH and Gas-fired WH using natural draft (EL 0)	0.4%	7.6%
HPWH and Gas-fired WH using natural draft (EL 1)	0.0%	5.2%
HPWH and Gas-fired WH using natural draft (EL 2)	0.1%	4.8%
HPWH and Gas-fired WH using power vent (EL 3)	0.0%	9.4%
HPWH and Gas-fired WH using power vent (EL 4)	0.0%	9.1%
HPWH and Gas-fired WH using power vent (EL 5)	0.0%	8.6%
HPWH and Gas-fired WH using condensing technology (EL 6)	0.0%	0.1%

Figure 9-A.2.2 shows the total effect on shipments of electric storage water heaters in the case of a standard level that would require a heat pump design. The figure shows projected shipments without switching and projected shipments in the cases of heat pump water heater switching to gas-fired water heater using natural draft (EL 2), power vent (EL 3), and condensing technology (EL 6).

^a For new construction, DOE began with a subset of those RECS households having electric water heaters that were built in the most recent period before the survey.

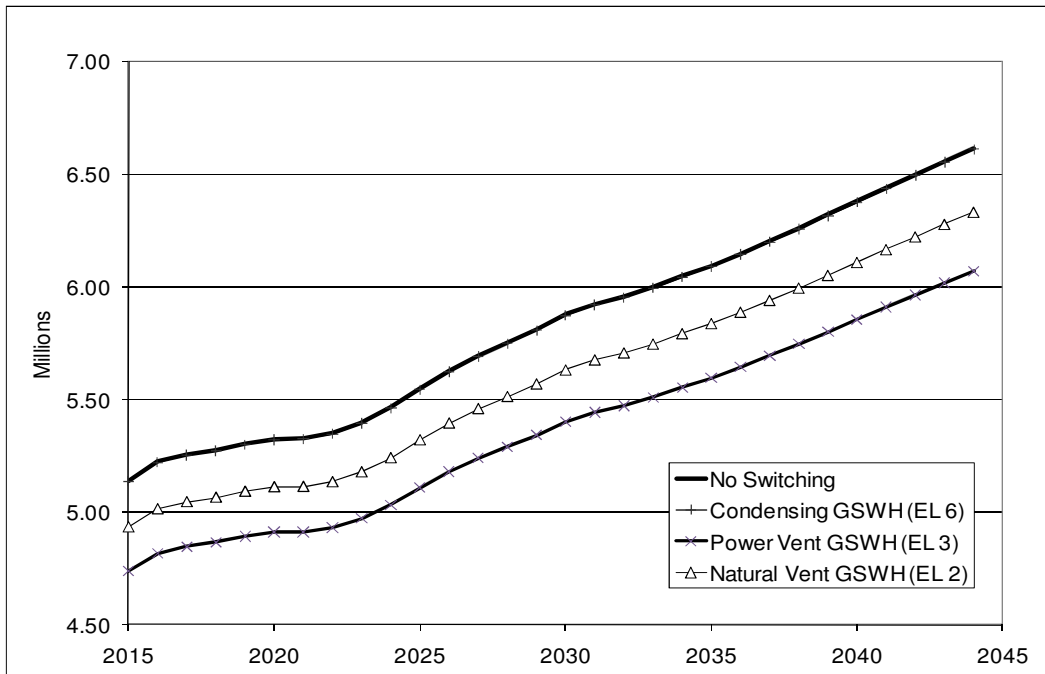


Figure 9-A.2.2 Shipments of Electric Storage Water Heaters Given a Standard Requiring Heat Pump Design, Accounting for Switching to Gas Water Heaters

9-A.3 SWITCHING FROM LARGE WATER HEATERS IN THE CASE OF TSL 5 AND TSL 6

As discussed in chapter 10, TSLs 5 and 6 include efficiency levels that require heat pump technology for electric storage water heaters with rated storage volumes at and above 56 gallons, and efficiency levels that require condensing technology for gas-fired storage water heaters with rated storage volumes at and above 56 gallons. These TSLs would present consumers of large water heaters with a total installed cost that could lead some of them to consider alternatives to purchasing a new large water heater. This might occur in either replacement or new construction applications. To estimate the likely incidence of switching away from large-volume units under TSL 5 and TSL 6, DOE considered several alternatives to purchasing a large water heater, as well as constraints that would likely limit their adoption. Figure 9-A.3.1 shows the general approach.

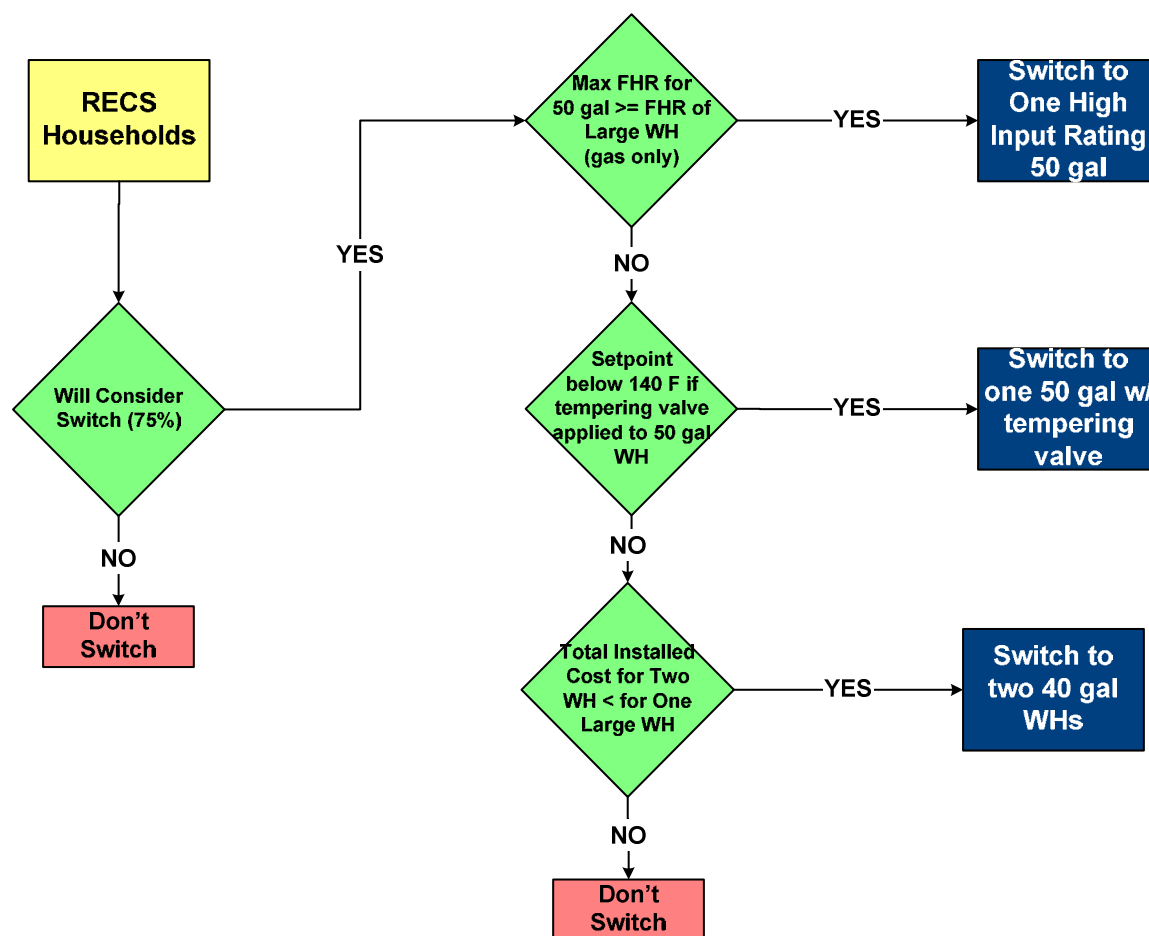


Figure 9-A.3.1 Equipment Switching Flowchart

First DOE considered factors that would cause some households to choose not to install an alternative to a new large-volume unit. Most important is the need for emergency replacement, which, according to comments on the NOPR could account for as much as 95 percent of water heater replacements.¹⁰ This may preclude consideration of switching, which would usually take more time. In addition, based on shipments data from AHRI,¹¹ equipment stock information from AEO 2010,² and data from RECS 2005¹² on the fraction of households with a gas furnace that also have a gas water heater, DOE determined that at least 15 percent of furnace shipments go to households that are switching from non-condensing to condensing gas furnace and also have a gas water heater.^b Some of these households may decide to install a

^b AHRI shipment data shows that condensing furnace shipments represented 43% of all gas furnace shipments in 2008. AEO 2010 equipment stock data shows that the stock weighted efficiency for gas furnaces in 2008 is about 82.5 AFUE. This indicates that about 70% of households have a non-condensing furnace. Condensing furnaces started to become available in the 1990's, but most of their shipments have come in the last 10 years. Given that the average lifetime of gas furnaces is 20 years or more, DOE concluded that most replacements are of non-condensing gas furnaces and that at least 20% of these switch to condensing furnaces in order to match the most recent shipments data. According to RECS 2005 about 75% of gas furnaces installations also have a gas storage water heater. In sum, about 15% of gas furnace shipments that switch from a non-condensing to a condensing furnace have a gas storage water heater.

condensing gas water heater to avoid complex venting system modifications. Another factor that could cause some households to choose not to install an alternative to a new large-volume unit is if the homeowner assigns a high weight to the operating cost advantages of a heat pump water heater or a gas condensing water heater. DOE judged that the above factors would reduce the fraction of installations that might consider an alternative to purchasing a large-volume water heater by 25 percent. DOE selected these households at random from the RECS sample.

One alternative applicable to both gas-fired storage water heaters and electric storage water heaters involves installing a small-volume water heater, increasing the setpoint and applying a tempering valve. DOE believes that this strategy would only be viable for a fraction of 66-gallon units. To assess the viability of this approach for each of the sample households with 66-gallon water heaters, DOE calculated whether the first-hour rating of the small-volume water heater with a tempering valve would meet the first-hour rating of the existing 66-gallon water heater without exceeding a 140 degree F setpoint. If so, DOE assumed the household would choose this option. The results of DOE's analysis indicate that switching away from a large-volume water heater using this strategy would occur in 20 percent of large-volume electric storage water heater installations and in 4.4 percent of large-volume gas-fired storage water heater installations.

For gas-fired storage water heaters, DOE considered the approach of switching to a small-volume unit with high input capacity. DOE understands that designs for units below 56 gallon rated volume that have very high rated input (e.g., 75 kBtu/hr) are not common. There are some 50-gallon models with an input of 65 kBtu/hr; these designs usually incorporate a 5-inch internal flue tube (instead of 4-inch), and the tank is usually taller to accommodate the same water storage volume. These units are likely to require venting modifications (upgrade to 4-inch vent). In addition, for many installations the input rate for the existing 66-gallon or larger unit is already 55 kBtu/hr or higher, and a 50-gallon unit with a high-capacity burner may not satisfy the household hot water requirements. DOE accounted for the above constraints, as well as for the higher cost of a 50-gallon unit with a high-capacity burner, to estimate the fraction of installations that would switch to a small-volume unit with high input capacity. DOE did not use this strategy for electric storage water heaters since nearly all volume sizes have similar-sized heating elements. The results of DOE's analysis indicate that switching away from a large-volume water heater using this strategy would occur in 6.7 percent of large-volume gas-fired storage water heater installations.

DOE then considered the alternative of installing two small-volume gas or electric storage water heaters. For each sample household with a large-volume water heater that, according to DOE's estimation, would not adopt either of the two strategies described above, DOE first considered space constraints that would limit this approach, depending on the water heater location. For those households judged not to have such constraints, DOE compared the total installed cost of either a heat pump water heater or a gas condensing water heater with the alternative of installing two small-volume units. For the cost of this alternative, DOE used information from a consultant report.² DOE assumed that households would choose to install two small-volume units if their total installed cost was 10 percent or more less than the cost for a heat pump water heater or a gas condensing water heater. The results of DOE's analysis indicate that

switching away from a large-volume water heater using this strategy would occur in 16.6 percent of large-volume electric storage water heater installations and in 11.7 percent of large-volume gas-fired storage water heater installations.

The final results of DOE's analysis indicate that switching away from a large-volume water heater would occur in 37 percent of large-volume electric storage water heater installations and in 22 to 23 percent of large-volume gas-fired storage water heater installations. Table 9-A.3.1 shows the percentage of households estimated to switch using each of the considered strategies.

Table 9-A.3.1 Estimated Percent of Base Case Electric Water Heater Shipments that Would Switch to Gas-Fired Water Heaters

Equipment Switch Type	Fraction of Total Shipments	Percent that Switch (%)	
		Installations	Total shipments
Gas Storage Water Heaters (TSL 5)	3.9%	22.8%	0.9%
One 65 gallon to one 50 gallon (High Input Rating)	2.0%	12.9%	0.3%
One 65 gallon to one 50 gallon (Tempering Valve)		8.5%	0.2%
One 65 gallon to two 40 gallon		7.5%	0.2%
One 75 gallon to two 40 gallon	1.9%	16.2%	0.3%
Gas Storage Water Heaters (TSL 6)	3.9%	21.8%	0.8%
One 65 gallon to one 50 gallon (High Input Rating)	2.0%	12.9%	0.3%
One 65 gallon to one 50 gallon (Tempering Valve)		8.5%	0.2%
One 65 gallon to two 40 gallon		5.5%	0.1%
One 75 gallon to two 40 gallon	1.9%	16.2%	0.3%
Electric Storage Water Heaters (TSL 5 and 6)	8.8%	36.7%	3.2%
One 66 gallon to one 50 gallon (Tempering Valve)	3.5%	50.0%	1.8%
One 66 gallon to two 40 gallon		8.0%	0.3%
One 80 gallon to two 40 gallon	4.0%	20.5%	0.8%
One 119 gallon to two 40 gallon	1.3%	28.2%	0.4%

9-A.3.2 Equipment and Installation Costs for Equipment Switching

DOE estimated that the additional manufacturer cost for a higher rated input capacity (65 kBtu/hr or higher) for 50 gallon gas-fired water heater on average is about \$50 based on a consultant report.²

For additional installation cost from installing a tempering valve is on average \$157 for gas-fired storage water heaters and \$145 for electric storage water heaters. See Appendix 8A for details.

The average addition cost of installing two water heaters, above the cost for one large water heater, is shown in tables 9-A.4.1 to 9-A.4.4 and is based on a consultant report.²

Table 9-A.3.2 Additional Cost for installing two 40 gallon GSWHs: Replacement

Description	Crew	Labor Hours	Unit	Bare Costs (2009\$)			Total incl. O&P
				Mat.	Labor	Total	
Provide gas supply, vent and water for two water heaters	2 Plum	2.0	Ea.	\$126.00	\$102.38	\$228.38	\$292.28
Install second gas water heater	2 Plum	0.5	Ea.	\$3.00	\$25.60	\$28.60	\$41.72
Total							\$334.00

Table 9-A.3.3 Added Cost for installing two 40 gallon GSWHs: New Construction

Description	Crew	Labor Hours	Unit	Bare Costs (2009\$)			Total incl. O&P
				Mat.	Labor	Total	
Provide gas supply, vent and water for 2 nd water heater	2 Plum	1.5	Ea.	\$90.00	\$76.79	\$166.79	\$214.26
Install second gas water heater	2 Plum	0.5	Ea.	\$40.00	\$51.19	\$91.19	\$120.84
Total							\$335.10

Table 9-A.3.4 Added Cost for installing two 40 gallon ESWHs: Replacement

Description	Crew	Labor Hours	Unit	Bare Costs (2009\$)			Total incl. O&P
				Mat.	Labor	Total	
Provide Elec. Supply for second heater	2 Plum	2.0	Ea.	\$135.00	\$85.65	\$220.65	\$277.06
Install second electric water heater	2 Plum	0.5	Ea.	\$55.00	\$21.41	\$76.41	\$92.64
Total							\$369.70

Table 9-A.3.5 Added Cost for installing two 40 gallon ESWHs: New Construction

Description	Crew	Labor Hours	Unit	Bare Costs (2009\$)			Total incl. O&P
				Mat.	Labor	Total	
Provide elec. Supply for 2 nd water heaters	2 Plum	1.0	Ea.	\$90.00	\$42.82	\$132.82	\$163.28
Install second electric water heater	2 Plum	1.0	Ea.	\$40.00	\$42.82	\$82.82	\$108.28
Total							\$271.56

9-A.3.3 Inputs to National Impact Analysis to Account for Switching Away from Large Water Heaters

Tables 9-A.4.5 to 9-A.4.7 show the inputs used in the NIA to account for switching from large gas-fired or electric storage water heaters to two smaller water heaters. By using these inputs DOE takes into account the extra standby losses experienced by two water heaters compared to one large water heater.

Table 9-A.3.6 Inputs to NIA for TSL 5 for Gas-fired Storage Water Heaters

Description	Annual Gas Use	Electricity Use	Installation Costs	Annual Maint. Cost	Repair Cost	Repair Year	Fraction of Shipments
EL 1 (Small Water Heaters)	15.5	0.0	\$1,164	\$11	\$24	8	96.1%
Equipment Switching	24.4	0.0	\$1,568	\$16	\$37	8	0.9%
EL 6 (Large Water Heaters)	15.7	55.7	\$2,066	\$8	\$46	9	3.0%
Shipment Weighted Avg.	15.6	1.7	\$1,194	\$11	\$25	8	100.0%

Table 9-A.3.7 Inputs to NIA for TSL 6 for Gas-fired Storage Water Heaters

Description	Annual Gas Use	Electricity Use	Installation Costs	Annual Maint. Cost	Repair Cost	Repair Year	Fraction of Shipments
EL 2 (Small Water Heaters)	15.0	5.9	\$1,238	\$11	\$24	8	96.1%
Equipment Switching	24.0	4.9	\$1,581	\$16	\$36	8	0.8%
EL 6 (Large Water Heaters)	15.7	55.7	\$2,066	\$8	\$46	9	3.0%
Shipment Weighted Avg.	15.1	7.4	\$1,265	\$11	\$25	8	100.0%

Table 9-A.3.8 Inputs to NIA for TSL 5 and 6 for Electric Storage Water Heaters

Description	Electricity Use	Installation Costs	Annual Maint. Cost	Repair Cost	Repair Year	Market Share
EL 5 (Small Water Heaters)	2344.9	\$693	\$2	\$21	6	91.2%
Equipment Switching	3419.9	\$1,117	\$3	\$30	6	3.2%
EL 6 (Large Water Heaters)	1926.7	\$1,703	\$4	\$57	8	5.6%
Shipment Weighted Avg.	2356.2	\$763	\$2	\$23	6	100.0%

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